AMENDED SPECIFICATION

IDS-2

Reprinted as amended under Section 11 of the Patents and Designs Acts, 1907 to 1939, in accordance with the Decision dated the seventeenth day of August, 1939, and the Supplementary Decision dated the sixteenth day of December, 1939, of the Superintending Examiner, acting for the Comptroller-General.

PATENT SPECIFICATION

Application Date: Nov. 18, 1935. No. 31877/35.

" " Feb. 27, 1936. No. 5880/36.

467,564

One Complete Specification Left: Nov, 12, 1936.

(Under Section 16 of the Patents and Designs Acts, 1907 to 1932).

Specification Accepted: June 18, 1937.

PROVISIONAL SPECIFICATION
No. 31877 A.D. 1935.

Method and Apparatus for Controlling the Temperature of Exothermic Reaction Chambers

We, ROBINSON BINDLEY PROCESSES LIMITED, a British Company, of 31, East Street, Epsom, in the County of Surrey, and ALFRED AUGUST AICHER, a British Subject, of 22, Holland Avenue, Wimbledon, London, S.W.20, do hereby declare the nature of this invention to be as follows:—

This invention relates to a method and apparatus for controlling the temperature of chambers in which an exothermic reaction is taking place.

According to the invention the temperature of the reaction chamber is maintained at the desired point by evaporative cooling. A liquid heated to its boiling point is supplied to a boiling chamber in thermal contact with the reaction chamber; the liquid boils off, the latent heat of vaporisation being taken from the reaction chamber, which is thereby maintained at the required temperature. The vapour is preferably condensed and led back to the boiling chamber, so that the cooling system forms a closed circuit. The liquid used for cooling is chosen so that its boiling point corresponds approximately to the temperature at which the reaction chamber is to be maintained; by varying the pressure under which the liquid boils, the temperature can be adjusted within fine limits.

In one apparatus for carrying out the invention, the boiling chamber is formed by the annular space between two concentric vertical tubes inserted in the reaction chamber. At their lower ends the tubes are connected together and provided with an inlet for the liquid. The upper end of the outer tube is closed while the upper end of the inner tube is open. The vapour produced by the boiling of the liquid in the space between the tubes passes down through the inner tube to an outlet, from which it passes to a condenser. The liquid from the condenser is raised by a pump to a receiver, from which it flows by gravity through a heater, which raises its temperature to boiling point, back into the boiling chamber. The level of liquid in the boiling chamber depends on the level in the receiver and this latter level is maintained by an overflow pipe which leads from the receiver to a liquid trap. The liquid trap also acts as a pressure chamber by means of which the pressure in the cooling system (and thus the boiling point of the cooling liquid) can be controlled. To this end, the pressure chamber is connected through a regulator valve with a source of compressed gas and is provided with a pressure gauge and with a safety valve. Alternatively, or in addition, the pressure chamber can be connected to a vacuum pump, so that the pressure in the cooling system (and thus the boiling point of the liquid) can be reduced.

The condenser of the apparatus above described may be replaced by a heat exchanger in which the heat of the vapour is given up and utilised for heating purposes of any kind, or it may be replaced by a vapour engine of any suitable con-

struction. The vapour from the boiling chamber may be led to a condenser situated above the raised receiver; any small quantity of liquid which condenses in the rising pipe may be re-vaporised by means of a suitably positioned heater. In this way the pump may be eliminated and the cooling system is rendered independent of any moving parts. Other modifications of the apparatus described are also possible.

Owing to the fact that the co-efficient of transmission of heat to a liquid from a surrounding wall is much greater when the liquid is boiling than when it is not, the temperature difference between the reaction chamber and the cooling liquid is reduced to a minimum when the system of the present invention is employed. The system thus presents considerable advantages over systems which depend simply upon a circulating liquid.

Dated this 18th day of November, 1935.
A. A. THORNTON,
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For the Applicants.

PROVISIONAL SPECIFICATION
No. 5880 A.D. 1936.

Method and Apparatus for Controlling the Temperature of Exothermic Reaction Chambers

We, ROBINSON BINDLEY PROCESSES LIMITED, a British Company, of 31, East Street, Epsom, Surrey, England, and ALFRED AUGUST AICHER, a British Subject, of 22, Holland Avenue, Wimbledon, London, S.W.20, do hereby declare the nature of this invention to be as follows:—

This invention relates to a method and apparatus for controlling the temperature of chambers in which an exothermic reaction is taking place. More particularly, the invention has reference to apparatus of the kind forming the subject of our co-pending application for Letters Patent No. 31877 of 1935.

In the apparatus described in the specification of that application the temperature of the reaction chamber is maintained at the desired point by evaporative cooling. The boiling chamber for the cooling liquid is formed by concentric vertical tubes inserted in the reaction chamber. At their lower ends the tubes are provided with a common inlet through which the cooling liquid, heated to a temperature near its boiling point, can enter the annular space between the tubes. The upper end of the outer tube is closed, while the upper end of the inner tube is open. The vapour produced by the boiling of the liquid in the annular space passes down through the inner tube to an outlet. The vapour is then condensed and subsequently returned to the boiling chamber. By varying the pressure in the cooling system, the boiling point of the cooling liquid (and thus the temperature at which the reaction chamber is maintained) can be adjusted within fine limits.

In such apparatus, when the liquid in the annular space is actually boiling, its apparent density will be less than the actual density of the liquid, owing to the presence of vapour bubbles in the liquid. If now the pressure within the cooling system is increased in order to raise the boiling point of the liquid and thus the temperature at which the reaction chamber is maintained, the liquid will temporarily cease to boil. Owing to the disappearance of the vapour bubbles, the apparent density of the liquid in the annular space will increase and consequently the height of the liquid column will fall. The upper part of the outer tube is thus no longer in contact with the cooling liquid and can effect no appreciable cooling of the reaction chamber.

The apparatus described is particularly intended for controlling the temperature of catalytic reactions. In such cases it is important that the catalyst itself should not be overheated and it is therefore arranged in a cylindrical bed immediately surrounding the cooling tubes. It will be clear, however, from the foregoing explanation that in certain circumstances the upper part of the cooling tubes may cease to have any appreciable cooling effect.

According to the present invention, therefore, the catalyst is arranged around the lower part only of the tubes, which are allowed to project above the top of the catalytic bed. This ensures that the catalyst is always adequately cooled and overheating is prevented.

This arrangement has also a further advantage. The fluid which is to take part in the reaction should when it reaches the catalytic bed be at a temperature as near as possible to that of the catalyst itself. A preheater can, of course, be used to raise the temperature of the gas or other

fluid to the required level, but it is always possible that the temperature may vary between the preheater and the catalytic bed. With the arrangement above described, however, the protruding portions of the tube (which are normally at substantially the same temperature as the catalyst) adjust the temperature of the incoming gas (which preferably enters at the upper end of the reaction chamber) in a most efficient manner, before it reaches the catalytic bed.

Dated this 27th day of February, 1936.

A. A. THORNTON,
Chartered Patent Agents,
7, Essex Street, Strand, London, W.C.2.

COMPLETE SPECIFICATION

Method and Apparatus for Controlling the Temperature of Exothermic Reaction Chambers

We, ROBINSON BINDLEY PROCESSES LIMITED, a British Company, of 31, East Street, Epsom, in the County of Surrey, and ALFRED AUGUST AICHER, a British Subject, of 22, Holland Avenue, Wimbledon, London, S.W.20, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to a method and apparatus for controlling the temperature of chambers in which an exothermic reaction is taking place. The method and apparatus of the present invention are of the known kind in which the temperature of the reaction chamber is maintained at the desired point by cooling it by the evaporation of a liquid and adjusting the temperature at which the liquid boils. The liquid used for cooling is naturally so chosen that its boiling point corresponds approximately to the temperature at which the reaction chamber is to be maintained; by varying the pressure under which the liquid boils, the temperature can be adjusted more exactly.

The temperature controlling systems of this kind which have been proposed hitherto are not adapted to effect control with the uniformity and accuracy required. We have found that to maintain the temperature sufficiently uniform throughout the reaction chamber, the following essential conditions must be observed. The boiling liquid actually in contact with the walls of the reaction chamber must be kept in circulation, so as to prevent the formation of a layer of vapour which would reduce the thermal conductivity between the walls of the reaction chamber and the liquid. Accordingly only a relatively thin layer of the boiling liquid must be employed and to ensure adequate circulation fresh liquid must be introduced at the lower end of the boiling chamber while the vapour is withdrawn from the upper end. If the boiling liquid is contained in a bath of relatively large capacity, in which the reaction chamber is immersed, or is contained in conduits of circular cross section arranged within the reaction chamber (one or other of which methods have usually been adopted in prior proposals) the formation of vapour films cannot be avoided. Equally it is impossible to obtain satisfactory results if (as has been suggested) the vapour is merely condensed in the upper part of the boiling chamber and allowed to trickle back by gravity. We have also found it to be essential that the liquid in contact with the walls of the reaction chamber should be boiling vigorously. Accordingly, the liquid should be heated to its boiling point before it is introduced into the boiling chamber. Finally, where (as will usually be the case) the reaction materials are passed continuously through the reaction chamber, we have found it essential that their flow should be in a direction opposed to the direction of flow of the cooling medium.

With these requirements in view, the method of the present invention for controlling by cooling the temperature at which an exothermic reaction takes place consists in introducing into the lower part of a boiling chamber adjacent the walls of the reaction chamber a liquid previously heated to its boiling point, maintaining in movement in close contact with the walls of the reaction chamber a thin layer of vigorously boiling liquid, withdrawing from the upper end of the boiling chamber the vapour formed by the boiling liquid and adjusting the pressure under which the liquid boils.

Apparatus in accordance with the invention for carrying out this method of temperature control comprises a reaction chamber, a boiling chamber defined between a wall of the reaction chamber and a second wall closely adjacent thereto, means for heating a liquid to its boiling point and introducing it into the lower part of the boiling chamber, means for withdrawing the vapour from the upper

part of the boiling chamber and adjustable means for controlling the pressure in the boiling chamber. Preferably means are provided for condensing the vapour produced in the boiling chamber and leading it back into the boiling chamber, so that a closed circuit is formed. The reaction and boiling chambers may conveniently be formed by concentric tubes; preferably three such tubes are provided, the spaces between them forming the reaction chamber, the boiling chamber and a passage serving to receive the vapour produced in the boiling chamber.

It has already been proposed in the specifications of Letters Patent Nos. 390186 and 390504 to control the temperature of a chamber in which an exothermic reaction is taking place by inserting in the chamber a number of tubes each closed at its upper end and provided with an inner concentric tube open at its upper end. Liquid is supplied to the lower ends of the outer tubes and evaporating under the heat of the reaction and thereby cooling the reaction chamber forms a climbing film of liquid. The vapour produced passes away downwardly through the inner tubes. This proposed apparatus was not provided with means for adjusting the pressure under which the liquid boiled nor with means for preheating the liquid to its boiling point before introducing it into the annular spaces between the concentric tubes. For these reasons the apparatus is not adapted to give the precise but flexible control of temperature which is achieved by the use of the present invention.

Apparatus for carrying out the present invention is shown in the accompanying drawing, which is of a somewhat diagrammatic character. In the apparatus shown the reaction chamber and the boiling chamber are formed by three coaxial tubes 1, 2, and 3, the space between tubes 1 and 2 forming the reaction chamber and the space between tubes 2 and 3 forming the boiling chamber. At their lower ends tubes 2 and 3 are connected together and provided with an inlet for the liquid. The upper end of tube 2 is closed, while the upper end of tube 3 is open. The liquid in the boiling chamber boils off, the latent heat of vaporisation being taken from the reaction chamber. The vapour thus produced passes down through tube 3 to an outlet, from which is passes through a pipe 4 to a condenser 5. The liquid from the condenser is raised by a pump 6 through a pipe 7 to a receiver 8, from which it flows by gravity through a pipe 9 to a heater 10, which raises its temperature to boiling point, and thence through a pipe 11 back into the boiling chamber. The level of liquid in the boiling chamber depends on the level in the receiver 8 and this later level is maintained by an overflow pipe 12 which leads from the receiver to a liquid trap 13. The liquid trap also acts as a pressure chamber by means of which the pressure in the cooling system (and thus the boiling point of the cooling liquid) can be controlled. To this end, the pressure chamber 13 is connected through a pipe 15 provided with a regulator valve 16 with a source of compressed gas 14 and is provided with a pressure gauge 17 and with a safety valve 18. Alternatively, or in addition, the pressure chamber can be connected to a vacuum pump, so that the pressure in the cooling system (and thus the boiling point of the liquid) can be reduced.

Owing to the fact that the co-efficient of transmission of heat to a liquid from a surrounding wall is much greater when the liquid is boiling than when it is not, the temperature difference between the reaction chamber and the cooling liquid is reduced to a minimum when the system of the present invention is employed. The system thus presents considerable advantages over systems which depend simply upon a circulating liquid.

When the liquid in the annular space between tubes 2 and 3 is actually boiling, its apparent density will be less than the actual density of the liquid, owing to the presence of vapour bubbles in the liquid and its surface 22 will accordingly lie above the level of the liquid in the receiver 8. If now the pressure within the cooling system is increased in order to raise the boiling point of the liquid, and thus the temperature at which the reaction chamber is maintained, the liquid will temporarily cease to boil. Owing to the disappearance of the vapour bubbles, the apparent density of the liquid in the annular space will increase and consequently the surface of the liquid column will fall to the position indicated in dotted lines at 23. The upper part of the tube 2 is thus no longer in contact with the cooling liquid and can effect no appreciable cooling of the reaction chamber. The apparatus described is particularly intended for controlling the temperature of catalytic reactions. In such cases it is important that the catalyst itself should not be overheated and it is therefore arranged in a cylindrical bed immediately surrounding the cooling tube 2. It will be clear, however, from the foregoing explanation that in certain circumstances the upper part of the cooling tube may cease to have any appreciable cooling effect. Accordingly the catalyst should, as is indicated in the drawing, be arranged around the lower part only of the tube 2,

which is allowed to project above the top of the catalytic bed. This ensures that the catalyst is always adequately cooled and overheating is prevented. This arrangement has also a further advantage. The fluid which is to take part in the reaction should when it reaches the catalytic bed be at a temperature as near as possible to that of the catalyst itself. A preheater can, of course, be used to raise the temperature of the gas or other fluid to the required level, but it is always possible that the temperature may vary between the preheater and the catalytic bed. With the arrangement above described, however, the protruding portion of the tube 2 (which is normally at substantially the same temperature as the catalyst) adjusts the temperature of the incoming gas (which preferably enters at the upper end of the reaction chamber through a tube 24 and leaves at the lower end through a tube 25) in a most efficient manner, before it reaches the catalytic bed.

The condenser 5 and pump 6 of the apparatus above described may be omitted and the vapour from the boiling chamber led through a pipe 19 to a condenser 20 situated above the receiver 8, any small quantity of liquid which condenses in the rising pipe being re-vaporised by means of a heater 21, all as indicated in broken lines on the drawing. In this way the pump may be eliminated and the cooling system is rendered independent of any moving parts.

The condenser 5 or 20 of the apparatus above described may take the form of a heat exchanger in which the heat of the vapour is given up and utilised for heating purposes of any kind, or it may be replaced by a vapour engine of any suitable construction.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A method of controlling by cooling the temperature at which an exothermic reaction takes place, which consists in introducing into the lower part of a boiling chamber adjacent the walls of the reaction chamber a liquid previously heated to its boiling point, maintaining in movement in close contact with the walls of the reaction chamber a thin layer of vigorously boiling liquid, withdrawing from the upper end of the boiling chamber the vapour formed by the boiling liquid and adjusting the pressure under which the liquid boils.

2. Apparatus for controlling by cooling the temperature at which an exothermic reaction takes place, comprising a reaction chamber, a boiling chamber defined between a wall of the reaction chamber and a second wall closely adjacent thereto, means for heating a liquid to its boiling point and introducing it into the lower part of the boiling chamber, means for withdrawing the vapour from the upper part of the boiling chamber and adjustable means for controlling the pressure in the boiling chamber.

3. Apparatus in accordance with claim 2 and comprising return means for condensing the vapour produced in the boiling chamber and leading it back into the boiling chamber.

4. Apparatus in accordance with claim 3 wherein the return means comprise a condenser situated below the level of the boiling chamber and a pump for raising the liquid condensed.

5. Apparatus in accordance with claim 3 wherein the return means comprise a condenser situated above the level of the boiling chamber and a heater for re-vaporising any liquid condensed below the level of the condenser.

6. Apparatus in accordance with any of claims 2 to 5 wherein the reaction chamber and the boiling chamber are formed by coaxial tubes.

7. Apparatus in accordance with claim 6 and comprising three coaxial tubes, the spaces between which form the reaction chamber, the boiling chamber and a passage serving to receive the vapour produced in the boiling chamber.

8. Apparatus in accordance with any of claims 2 to 7 and comprising a catalyst located in the reaction chamber, wherein the top surface of the catalyst is below the normal surface level of the boiling liquid in the boiling chamber.

9. The improved apparatus for controlling the temperature of exothermic reaction chambers, substantially as herein described.

Dated this 12th day of November, 1936.

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For the Applicants.

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[This Drawing is a reproduction of the Original on a reduced scale.]